SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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NUMERICAL INVESTIGATION OF EFFECT OF GRAIN CONFIGURATION ON START-UP TRANSIENT IN SOLID ROCKET MOTORS

Abstract

Start-up transient is a very short period of the motor operation which is controlled by complex heat, mass and momentum transfer processes. Accurate prediction of ignition transient is very important in the design of solid rocket motor. A numerical model based on conductive heat transfer in solid propellant coupled to mass balance equation is used in the present study to predict the start-up transient in solid rocket motor with different grain configurations. Equivalent cylindrical port is considered for complex port configuration for ease of modelling and axi-symmetric model is used throughout the motor. Runge-Kutta fourth order time stepping scheme is applied for solving the governing mass balance equation which is a first order ordinary differential equation. Heat conduction equation in propellant is solved by a transient non-linear implicit finite element heat transfer code (weighted residual Galerkin's formulation) to estimate the temperature distribution. Temporal convective and radiative heat transfer from combustion products of igniter and propellant to the propellant grain surface is accounted using the heat transfer co-efficients computed along the propellant grain based on the empirical equations available in literature. Critical ignition temperature criteria is adopted for the computation of flame spreading and propellant grain burn back profile. In order to capture the severe thermal gradients in the propellant, an in-built subroutine is used for generating non-uniform finite mesh (quadrilateral elements) at every millisecond time step in the unburned propellant. Start-up transient numerical model is validated with the hot fired test data of ISRO's largest solid booster (S200 motor). Numerical investigations are conducted to study the effect of different grain configurations on flame spreading, ignition delay, pressurisation rates, ignition peak pressure, velocity and acceleration of combustion products in the port during ignition of motor. Developed numerical tool can be used for accurate prediction of ignition transient in any solid rocket motor without conducting expensive tests.